Comprehensive Survey on Image Feature Extraction Techniques

Prashant Aglave[1] V.S. Kolkure[2]
[1,2]Department of Electronics Engineering
[1,2]Bharatratna Indira Gandhi College of Engineering, Affiliated to Solapur University, Solapur, Maharashtra, India

Abstract— Recent industrial applications require object recognition and tracking capabilities. These applications require real-time performance. Feature extraction is one of the most important steps for image processing. This feature extraction method is method to detect a particular object in image. So in this paper, we focus our review on the latest development in image feature extraction and provide a comprehensive survey on image feature extraction methods. Different algorithms are used for image processing like Scale-invariant feature transform (SIFT), Speeded Up Robust Features (SURF). This paper gives an overall idea of general methods of Feature extraction and gives significance of ORB over SIFT and SURF algorithm. Use of ORB provides rotation invariance of both train image and query image.

Key words: SIFT, SURF, ORB

I. Introduction

Feature extraction plays very important role in image processing, which is used for separating image parts based on the some special characteristics. It can also be referred as streaming, which means separating some parts from images. The term 'feature' refers to remote sensing of the scene objects with similar characteristics. Some of main feature in an image are edges, corner points, blobs etc.

Edges are the sets of point in an image which has strong magnitude. Edge can be of any shape, it is a boundary between the two images. Corner and interest points are feature in an image, which has two dimensional structures. Blobs are the complementary description of image structures in terms of regions. A ridge is a feature that forms a continuous elevated crest for some distance. Based on these types of features, there are different types of feature detection algorithms. Like Sobel operator, canny edge detector, Features from accelerated segment test (FAST) are used for feature detection. Feature detection is one of the image processing operations. Feature detection is first operation performed on an image, which examines each and every pixel of an image to see is there any feature present at that pixel. Computer vision algorithms uses feature detection technique as a first step in image processing, so feature detectors have been developed in large numbers.

Once features have been detected using one of the feature detectors, then that features can be extracted using some feature extraction algorithm. This extraction may consist of some considerable amounts of image processing. The result is known as a feature vector. In pattern recognition and in image processing, feature extraction is a special form of dimensionality reduction.

II. Feature Extraction

Feature extraction is one of the inspiring works in image processing. The significance of the feature extraction is most appropriately defined referring to the purpose it serves. Feature extraction is that of extracting from the raw data. Watchful selection of features is the most important phase in image classification. In the feature extraction process the dimensionality of data is reduced. This is always necessary due to the technical limits in memory and computation time. A good feature extraction on scheme should preserve and improve that feature of the input data which create distinct pattern classes separate from each other. Feature extraction encompasses shortening the amount of resources which is necessary to define a large set of data.

III. Overview of Methods

Today many industrial applications require object recognition and tracking capabilities. Many feature-based algorithms are well-suited for such operations. Most of the papers reviewed under the project are based on basic algorithms like SIFT, SURF and their variants. So this literature survey provides information about feature extraction using them. Yan Ke and Rahul Sukthankar [5] covers the feature extraction using SIFT algorithm. Herbert Bay [4] explains the feature extraction using SURF algorithm. ORB algorithm is explained by Ethan Rublee in [1] as an alternative to the above two techniques. So from this literature survey we can say that, different techniques used for feature extraction are:

(1) Scale-Invariant Feature Transform (SIFT) [5]
(2) Speeded Up Robust Features (SURF) [4]
(3) Oriented FAST and Rotated BRIEF (ORB) [1] etc.

A. *Scale-Invariant Feature Transform (SIFT):*

SIFT (Scale Invariant Feature Transform) algorithm proposed by Lowe in 2004 [7] to solve the image rotation, scaling, and affine deformation, viewpoint change, noise, illumination changes, also has strong robustness. The SIFT algorithm has four main steps: (1) Scale Space Extrema Detection, (2) Key point Localization, (3) Orientation Assignment and (4) Description Generation.

The first stage is to identify location and scales of key points using scale space extrema in the DoG (Difference-of-Gaussian) functions with different values of σ, the DoG function is convolved of image in scale space separated by a constant factor k as in the following equation.

$$D(x,y,\sigma)=(G(x,y,k\sigma)-G(x,y,\sigma))*I(x,y) \quad (1)$$

Where, G is the Gaussian function and I is the image. Now the Gaussian images are subtracted to produce a DoG, after that the Gaussian image subsample by factor 2 and produce DoG for sampled image. A pixel compared of 3×3 neighborhood to detect the local maxima and minima of D(x, y, σ). In the key point localization step, key point candidates are localized and refined by eliminating the key points where they rejected the low contrast points. In the orientation assignment step, the orientation of key point is obtained based on local image gradient. In description generation stage is to compute the local image descriptor for each key point based on image gradient magnitude and orientation at each image sample point in a region centered at key point [6], these samples building 3D histogram of gradient location and orientation; with 4×4 array location grid and 8 orientation bins in each sample. That is 128-element dimension of key point descriptor.

B. Speeded Up Robust Features (SURF):

SURF (Speeded Up Robust Features) [4] presents a novel scale- and rotation-invariant interest point detector and descriptor. It approximates or even outperforms previous schemes with respect to repeatability, distinctiveness, and robustness, yet can be computed and compared much faster. This is achieved by relying on integral images for image convolutions; by building on the strengths of the leading existing detectors and descriptors (e.g., using a Hessian matrix-based measure for the detector, and a distribution-based descriptor); and by simplifying these methods to the essential. This leads to a combination of novel detection, description, and matching steps. The detector is based on the Hessian matrix [11, 1], but uses a very basic approximation, just as DoG is a very basic Laplacian-based detector. It relies on integral images to reduce the computation time hence called the 'Fast-Hessian' detector. The descriptor, on the other hand, describes a distribution of Haar-wavelet responses within the interest point neighborhood. Again, integral images are exploited for speed.

C. ORB:

ORB is basically a fusion of FAST key point detector and BRIEF descriptor with many modifications to enhance the performance. ORB [1] builds on the well-known FAST key point detector and the recently-developed BRIEF descriptor; for this reason we call it ORB (Oriented FAST and Rotated BRIEF). Both these techniques are attractive because of their good performance and low cost. ORB includes,

- The addition of a fast and accurate orientation component to FAST.
- The efficient computation of oriented BRIEF features.
- Analysis of variance and correlation of oriented BRIEF features.
- A learning method for de-correlating BRIEF features under rotational invariance, leading to better performance in nearest-neighbour applications.

First it uses FAST to find key points, then apply Harris corner measure to find top N points among them. It also use pyramid to produce multiscale-features.

1) Feature Detection using FAST:

(1) Select a pixel 'P' in the image which is to be identified as an interest point or not. Let its intensity be 'Ip'.
(2) Select appropriate threshold value't'.
(3) Consider a circle of 16 pixels around the pixel under test. (See the image below)

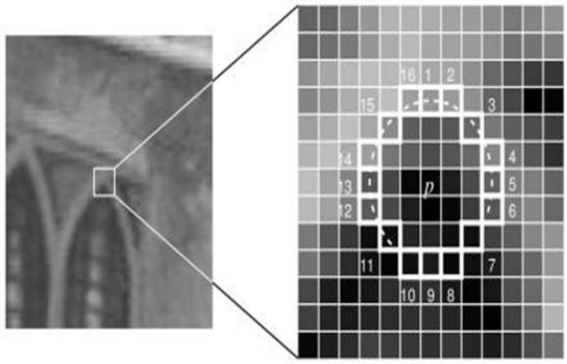

Fig. 1: Corner Point Selection in FAST

(4) Now the pixel P is a corner if there exists a set of 'n' contiguous pixels in the circle (of 16 pixels) which are all brighter than 'Ip+t', or all darker than 'Ip-t'. (Shown as white dash lines in the above image). 'n' was chosen to be 12.
(5) A high-speed test was proposed to exclude a large number of non-corners. This test examines only the four pixels at 1, 9, 5 and 13 (First 1 and 9 are tested if they are too brighter or darker. If so, then checks 5 and 13). If P is a corner, then at least three of these must all be brighter than 'Ip+t' or darker than 'Ip-t'. If neither of these is the case, then P cannot be a corner. The full segment test criterion can then be applied to the passed candidates by examining all pixels in the circle. This detector in itself exhibits high performance, but there are several weaknesses:

- It does not reject as many candidates for n < 12.
- The choice of pixels is not optimal because its efficiency depends on ordering of the questions and distribution of corner appearances.
- Results of high-speed tests are thrown away.
- Multiple features are detected adjacent to one another.

First 3 points are addressed with a machine learning approach. Last one is addressed using non-maximal suppression.

D. BRIEF Descriptor:

Binary Robust Independent Elementary Features (BRIEF) is a general-purpose feature point descriptor that can be combined with arbitrary detectors. It is robust to typical classes of photometric and geometric image transformations. Binary descriptors are becoming increasingly popular as a means to compare feature points very fast and while requiring comparatively small amounts of memory. The typical approach to creating them is to first compute floating-point ones, using an algorithm such as SIFT, and then to binarize them. ORB use BRIEF descriptors. But we have already seen that BRIEF performs poorly with rotation. So what ORB does is to "steer" BRIEF according to the orientation of key points. For any feature set of binary tests at location (xi, yi), define a 2xη matrix, which contains the coordinates of these pixels [1].

ORB discretizes the angle to increments of 2Π/30 (12 degrees), and constructs a lookup table of precomputed BRIEF patterns. As long as the key point orientation is consistent across views, the correct set of points will be used to compute its descriptor. The BRIEF descriptor is a bit string description of an image patch constructed from a set of binary intensity tests.

IV. RESPONSES OBSERVED IN ORB

Evaluate the combination of oFAST and rBRIEF, which is called ORB, using two datasets: images with synthetic in-plane rotation and added Gaussian noise, and a real-world dataset of textured planar images captured from different viewpoints. For each reference image, the oFAST keypoints and rBRIEF features are computed, targeting 500 keypoints per image. For each test image do the same, then perform brute-force matching to find the best correspondence [1].

- The synthetic test set with added Gaussian noise of 10. In figure 2.2,it can be seen that the standard BRIEF operator falls off dramatically after about 10 degrees. SIFT outperforms SURF, ORB has the best performance, with over 70% inliers.

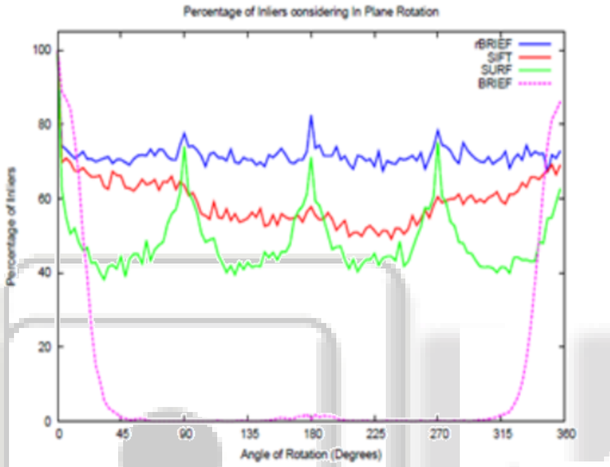

Fig. 2: The synthetic test set with added Gaussian noise of 10. [1]

- The inlier performance vs. noise.

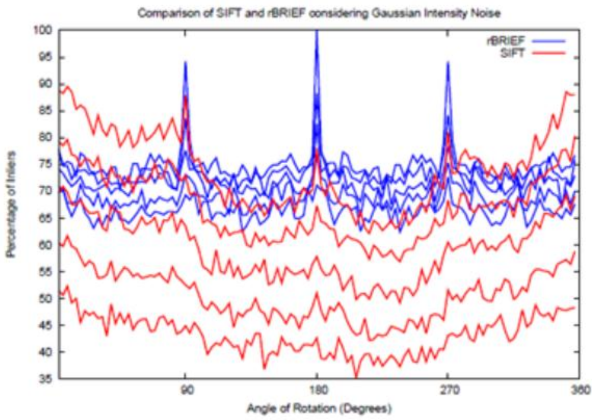

Fig. 3: The inlier performance vs. noise. Noise, at different noise levels [1]

The noise levels are 0, 5, 10, 15, 20, and 25. SIFT performance degrades rapidly, while rBRIEF is relatively unaffected. This proves the efficiency of ORB over SIFT and SURF.

V. FEATURE EXTRACTION COMPARISON

The existing methods SIFT and SURF actually relies on costly descriptors for detection and matching. SIFT and SURF has low time per frame rate. The SIFT (Scale-invariant feature transform) has Robust Histogram based description and it is very slow method. In order to overcome this drawbacks a system will be designed using very fast binary descriptor based on BRIEF, called ORB (Oriented FAST and Rotated BRIEF), which is rotation invariant and resistant to noise. Oriented FAST and Rotated BRIEF gives two orders of magnitude faster than SIFT.

VI. CONCLUSION

As few previous studies review both image feature extraction and image feature representation, which play a crucial role in multimedia processing community. So in this paper, we provide a comprehensive survey on the latest development in image feature extraction and image feature representation. In general the properties or feature is used to invent the techniques for extracting feature.

REFERENCES

[1] Ethan Rublee, Vincent Rabaud, Kurt Konolige Gary Bradski, **“**ORB: an efficient alternative to SIFT or SURF”**.**
[2] OndrejMiksik, “Evaluation of Local Detectors and Descriptors for Fast Feature Matching".
[3] Michael B. Holte, Cuong Tran, Mohan M. Trivedi, Thomas B. Moeslund,”Human Pose Estimation and Activity Recognition From Multi-View Videos: Comparative Explorations of Recent Developments".
[4] Herbert Bay, Tinne Tuytelaars, and Luc Van Gool,”SURF: Speeded Up Robust Features".
[5] Yan Ke, Rahul Sukthankar, “PCA-SIFT: A More Distinctive Representation for Local Image Descriptors", International Journal of Conceptions on Electronics and Communication Engineering,Vol. 1, Issue. 1, Dec 2013; ISSN: 2357 2809.
[6] ViniVidyadharan, and SubuSurendran, “Automatic Image Registration using SIFT-NCC”, Special Issue of International Journal of Computer Applications (0975 – 8887) , pp.29-32, June 2012.
[7] D. Lowe. “Distinctive Image Features from Scale-Invariant Keypoints”, Accepted for publication in the International Journal of Computer Vision, pp. 1-28, 2004.
[8] Edward Rosten and Tom Drummond, “Machine learning for high-speed corner detection", International Conference on Computer Vision,2008.
[9] Edward Rosten and Tom Drummond, “Fusing points and lines for high performance tracking",European Conference on Computer Vision,2006.
[10] Dilip K. Prasad, “Survey of The Problem of Object detection In Real Images",International Journal of Image Processing(IJIP),Volume(6):Issue(6):2012.
[11] Mikolajczyk, K., Schmid, “ An affine invariant interest point detector.ECCV.(2002) 128.
[12] S.Winder and M. Brown, “Learning Local Image Descriptors,” in Proc.CVPR’07, 2007